90-06244/1

Manitoba

Agriculture

Date: March 1990
Agdex No.: 541

Crop Management Facts

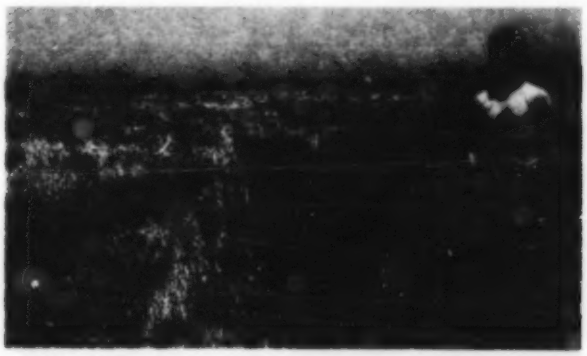
Copper Fertilizer Requirements on Peat Soils

Introduction

Peat Soils in Manitoba are often deficient in several nutrients which are essential for successful crop production. The major nutrients commonly required are nitrogen, phosphorus and potassium. The minor nutrients (micronutrients) required are copper, manganese and possibly boron. Micronutrients are required in very small amounts but are essential for healthy crop production. Copper is the micronutrient most likely to be in short supply on peat soils.

Copper Levels in the Soil

Mineral soils in Manitoba contain adequate copper for successful crop production. However, deep peat soils (soils deeper than 45cm or 18 in) are commonly deficient in copper. Shallow peat soils (soils less than 45 cm or 18 in) may also be copper deficient. Peat soils may be deficient for two main reasons. First, peat soils are almost entirely made up of organic matter which contains small amounts of copper in comparison to mineral soils. Second, about 99% of the copper in peat soils is unavailable for plant use.



Good crop of barley grown in soil fertilized with copper as compared to dead grass appearance of barley on copper deficient soil.

Factors Affecting Availability of Soil Copper

1) Dry soils increase the likelihood of copper deficiency. Moisture in the soil is necessary to move copper to the roots and to maximize the plant's ability to absorb nutrients.
2) Alkaline soils with pH above 7.0 are more likely to exhibit copper deficiency than acidic soils.
3) Very high levels of other soil nutrients may induce copper deficiency. Nitrogen, phosphorus and manganese have all been shown to induce a copper deficiency when present in unusually high amounts.

Copper Requirement and Function in Plants

Plants need copper to produce proteins which make up a good portion of the total plant material. Copper is also essential in the makeup of plant enzymes, some of which are instrumental in moving nutrients around within the plant. When a deficiency occurs, the plant will display some of the following symptoms: stunted growth, a delay or absence of flowering, reduced strength in stems, later maturity, poor disease resistance, and reduction in seed yield and quality.

Probability of Copper Deficiency Among Different Crops

Wheat, barley, oats, flax, canary grass, peas and alfalfa are known to respond to copper fertilization. Occasionally canola, rye and triticale respond with increased yields. Some evidence suggests that timothy seed may also respond to copper fertilizer. Feed quality of forage grasses has been shown to increase after fertilization with copper but yields are not necessarily improved.

Table 1
Responses of Various Crops to Copper Fertilizer on Copper-Deficient soils

Crop	Response
Wheat	High
Flax	High
Canary seed	High
Barley	Medium-High
Alfalfa	Medium-High
Timothy Seed	Medium
Oats	Medium
Corn	Medium
Peas	Low-Medium
Clovers	Low-Medium
Canola	Low
Rye	Low
Forage Grasses (Hay)	Low

Recent work in Manitoba indicates that the addition of copper fertilizer increased yields of barley from zero to as much as 2700-3800 kg/ha (50-70 bu/acre) in some field trials. In these trials, crops showed very poor response to other fertilizer inputs (e.g. nitrogen, phosphorus, potassium) without copper fertilization. In some cases, where a crop yield increase did not occur, feed and seed quality were improved. The responses of some commonly grown crops to copper fertilizer are shown in Table 1.

Identifying Copper Deficiency

1) Visual Copper Deficiency Symptoms

Visual symptoms are a result of the effects of copper on crop growth. Copper deficiency in cereals shows up as a whitening and twisting of leaf tips. On extremely deficient soils, cereal crops germinate and grow to a grass stage, but will not head out, or else they head out but set very poor seed. Weak stems, a wilted appearance and a rat-tailed head are other notable symptoms. The most prominent symptom is death of the youngest fully expanded leaf tip.

It is possible to confuse copper deficiency with other problems. Frost, hail, wind damage, drought, herbicide injury and nutrient interactions can all cause symptoms similar to those of copper deficiency.

Copper deficiency is evident in the twisting white die back of leaf tip in cereal crops

2) Plant Tissue Analysis

Plant tissue analysis can be useful in diagnosing copper deficiency. However, the interpretation of tissue analysis is difficult. Minimum copper levels in plant tissue have been determined for a range of crops, but these vary between crop species and varieties. As well, copper levels differ between parts of the plant and usually decline over the growing season. Furthermore, seemingly adequate levels of copper may be present in a plant which is suffering from a copper deficiency because of interactions with

Fig 1. The Relationship Between Barley Yields and Available Copper Levels in the Soil.

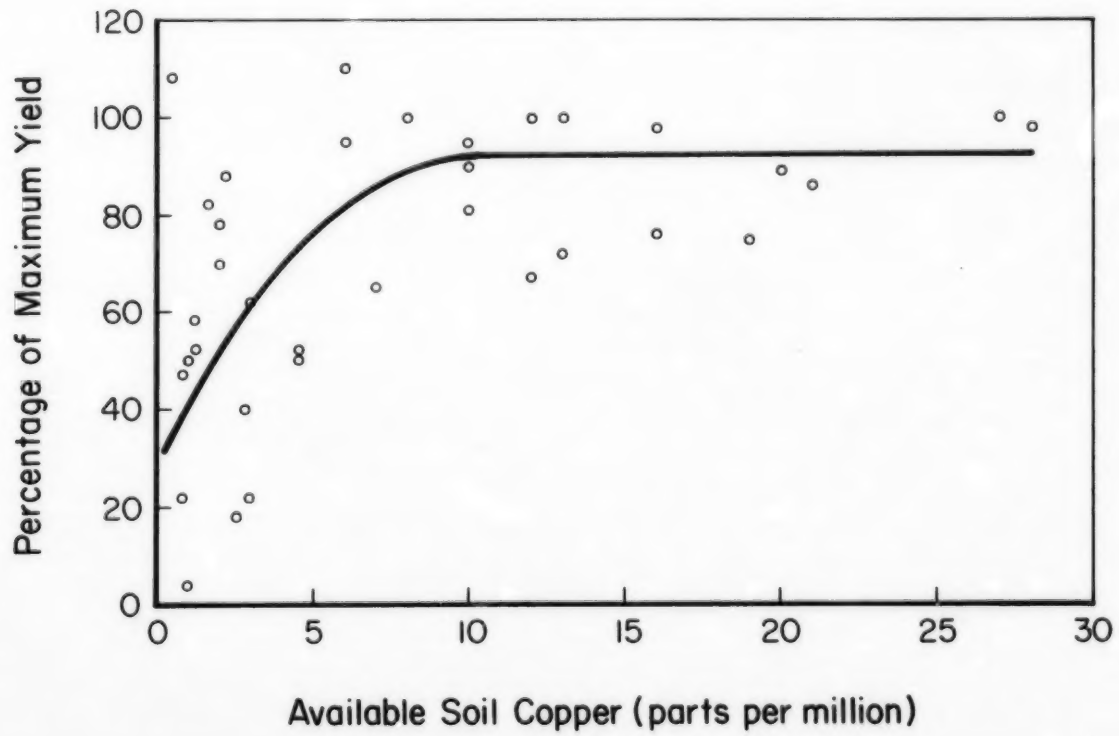


Table 2

Categories of Available Copper Levels in the Soil for the Production of Sensitive Crops

Available Copper Level in the Soil*			Category
ppm	kg/ha	lb/acre	
0-5	0-1.1	0-1.0	**Low.** Sensitive crops, including barley and wheat, often show a strong yield response to copper fertilizer. Application is usually economically justified.
6-12	1.2-2.7	1.1-2.4	**Medium.** Some yield response of crops sensitive to copper may occur in most years. Application may not be economically justified.
over 12	over. 2.7	over 2.4	**High.** Economic response to copper application is unlikely.

* D.T.P.A. extractable copper

other nutrients. Since differences in copper levels between healthy and deficient plants are often small to begin with, tissue analysis must also be interpreted with caution, and viewed in relation to other methods of assessing copper deficiency.

3) Soil Analysis

A recent study at the University of Manitoba, which was funded by the federal-provincial AGRI-FOOD agreement, found soil analysis to be a promising method for determining whether copper levels are adequate. As part of the study, different chemicals were used to extract, or remove, copper from soil samples. The results showed that the amounts of copper extracted from soil samples, using the chemical DTPA, was related to the availability of copper for plant growth in the field. In other words, this procedure could predict with some accuracy whether or not copper fertilizer would be required to grow a healthy crop. This test is available through the Provincial soil testing lab.

When testing for soil copper levels, spring or fall soil sampling to a depth of 15 cm (6 in.) is adequate. Copper is not highly mobile in soils and studies indicate that copper levels are similar in spring and fall.

Figure 1 indicates that barley yield response to applied copper (sulphate form) is greatest when soil copper levels are below five parts per million (ppm). Some response to copper application is seen when soil levels are between five and 12 ppm but very little response shows at levels greater than 12 ppm of available soil copper.

Critical levels of soil copper for crops which are sensitive to copper deficiencies are shown in Table 2. These levels apply to all sensitive crop species including wheat, flax, canary seed, barley, alfalfa, timothy seed, oats and corn. Peas and clovers may benefit from copper additions when gown on soils in the "low" category. More resilient crops such as canola, rye, and forage grasses are unlikely to demonstrate copper deficiency, even when grown on a soil with low copper levels.

4) Use of Test Strips

Crop yields on well drained peat soils can be quite variable over several years even if the fields have been adequately fertilized with major nutrients. This can occur for many reasons other than copper deficiency. Causes include diseases, poor weather and poorly adapted varieties. As well, copper deficiency symptoms may appear one year and disappear the next.

The most direct way for producers to determine whether poor crops on their peat soils are due to copper deficiency is to fertilize a small portion of the suspect field with copper. Yield comparison of the fertilized and unfertilized portion of the crop will determine whether the copper application was effective and whether it could be justified economically.

Of the four methods of identifying copper deficiency mentioned above, no one method by itself

Where there is a copper deficiency, seed fails to set resulting in poor head formation of cereal crops.

Table 3

1988 Barley Yields on Fields Fertilized with Copper Sulphate in Previous Years

Field Site	Year of Copper Application	1988 Barley Yield kg/ha (bu/acre) no copper	5 kg/ha copper (4.5 lb/acre)	10 kg/ha copper 9 lb/acre)
Piney	1985	700 (13)	no data	4310 (80)
River Hills	1985	160 (3)	no data	4470 (83)
Whitemouth	1986	970 (18)	3070 (57)	3340 (62)
Lac du Bonnet	1986	2910 (54)	3070 (57	4150 (77)
Riverton	1986	1990 (37)	3290 (61)	4200 (78)

is foolproof. The best approach is to combine information from two or three methods, get the advice of an experienced agronomist, and add some good common sense.

The Effect of Burning on Copper Availability

Some producers find that copper deficiency does not occur in the year following burning of a peat field. This is most likely due to the release of tied-up copper from the organic matter. Achieving a controlled surface burn on these soils is very difficult and this practice is controversial because of safety and environmental concerns.

Sources of Copper Fertilizer

Three copper fertilizer products are available on the market. These are copper sulphate (commonly called "bluestone"), EDTA copper chelate, and sequestered copper chelate.

Copper sulphate is the least expensive source per unit of copper, but is required in larger amounts and may be harder to apply than chelates. Copper sulphate is a granular product which is broadcast onto the soil with an air-type applicator or spin-type spreader. Both the EDTA and sequestered chelates are liquids which can be mixed with water and applied with a herbicide sprayer.

Shrivelled grain from copper deficient plants as compared to grain from normal plants.

The AGRI-FOOD project mentioned earlier found that a one-time application of copper sulphate, at 10 kg/ha (9 lbs/acre) of actual copper, was effective in increasing barley yields over four successive crop years at sites found to be copper deficient. It is believed that the residual effect of one copper sulphate addition may last for six to eight years. Copper chelates have also been found effective in increasing barley yields in Manitoba when applied to the soil, or, to a lesser extent, as a foliar application. Copper chelates do not provide copper for crops beyond the year of application.

1) Copper Sulphate

Copper sulphate (often called bluestone) is a blue colored crystal containing 25% actual copper by weight. It is available in various crystal sizes of which the most common are fine grade (about the consistency of sugar) and fertilizer grade (about the same size as standard fertilizer granules).

Copper sulphate has been shown to provide adequate plant available copper for at least four years when broadcast at the rate of 10 kg/ha of actual copper (9 lb/acre) and incorporated. A five kg/ha (4.5 lb/acre) application may be adequate for less extreme deficiencies and residual benefits will likely remain for at least three years.

Application in the fall is better than spring because it provides more time for the copper to dissolve. This is especially true when applying the larger fertilizer grade granules. Spring application usually provides good results with fine-grade products. Fine-grade copper sulphate may be more effective than fertilizer grade in the first year because the larger number of fine particles will be better dispersed through the root zone. Tillage is likely to minimize the difference between products over time.

Both fine granular and fertilizer grade products must be broadcast and well incorporated for maximum crop benefit. Incorporation distributes copper through a larger area of the root zone and increases uptake. A minimum of one pass with the cultivator or disc while working to a depth of 10-15 cm (4-6 in) is recommended. *The banding of copper sulphate is not recommended as the high copper concentration in the band is likely to injure seedlings.*

Warning

Copper sulphate is extremely corrosive when wet. Equipment should be thoroughly cleaned as soon after application as possible.

Application of the fine-grade copper sulphate may present a few problems. Spin spreaders are not designed to handle such a fine product. Therefore, a air-type granular applicator, such as those used for applying Avadex, is required to achieve an even distribution. Second, the fine-grade product naturally accumulates moisture if it is not kept in heated, dry storage. When damp, it may bridge in the hopper of the air applicator or stick to the metering roller. Mixing product from moist bags with product from drier bags, or even blending the copper sulphate with potash (0-0-60) before filling the hopper, greatly reduces these problems. Some producers have even been successful broadcasting with the spin spreader after blending moist copper sulphate fertilizer with potash, because the moist copper sulphate tends to stick to the larger potash granules and thereby resists settling out of the blend.

2) 7.5% Copper EDTA Chelate (Soil Applied)

This product is most easily applied onto the soil surface with a field sprayer before cultivating or harrowing in spring. Spray and incorporate prior to cultivation. Copper EDTA chelate is a good source of plant available copper for crops grown on deficient organic soils. No residual effect is to be expected.

3) 7.5% Copper EDTA Chelate (Foliar Applied)

When copper deficiency is noted early in the growing season, producers may try an application of 1.1 litres/acre copper EDTA as a foliar treatment. The foliar application is most beneficial when applied in the two to four leaf stage of cereals. Some producers have had excellent success with this method, but the limited research in Manitoba indicates foliar applications to be considerably less effective than preplant soil application (Table 4).

4) Sequestered Copper 5%

Sequestered copper is used at the same rates and applied in the same way as EDTA copper chelate. However, investigations in Manitoba have shown it to be less effective (Table 4). Preplant incorporated application can be expected to provide a greater benefit than foliar application, and spring application is superior to fall. Similar yield benefit may be expected from the preplant incorporated application of 2.2 litres/acre of sequestered copper or 1.1 litres/acre of EDTA chelate.

The Relative Effectiveness of Copper Products

The relative effectiveness of the various copper products was evaluated in experiments carried out in 1985 and 1986 using different rates and methods of application. Equally good results were achieved when using copper sulphate at 10 kg/ha (9 lb/acre) of actual copper or soil-applied EDTA chelate at 2.2 litres/acre providing the optimum rates and application methods were used. Sequestered chelate was found to be less effective. The results are shown in table 4.

Table 4

The Effect of Various Copper Fertilizer Products on the Yield of Barley

Copper Product	Time and Method of Application	Rate of Application		Average Yield of Barley (2 sites)	
				kg/ha	(bu/acre)
Copper Sulphate: broadcast and incorporate fertilizer grade*	fall	10 kg/ha	(9 lb/acre)	3070	57
	spring	10 kg/ha	(9 lb/acre)	2370	44
	spring	5 kg/ha	(4.5 lb/acre)	1890	35
EDTA Chelate: (7.5% coppper)	spring soil incorporated	2.2 litres/acre		2960	55
		1.1 litres/acre		2700	50
	foliar	1.1 litres/acre		2100	39
Sequestered Chelate: (5% copper)	spring soil incorporated	2.1 litres/acre		2480	46
	foliar	1.1 litres/acre		1460	27

* Direct comparisons of fertilizer grade and fine grade copper sulphate were not included in these experiments. However, evidence from other trials suggests that spring-applied fine grade and fall-applied fertilizer grade products are equally effective.

Table 5
Approximate Cost of Available Copper Fertilizer Products (1989 prices)

Product	Rate of Application		Cost/ha (cost/acre)	Expected Years of Effectiveness	Cost/ha (cost/acre) per year
Copper Sulphate:					
• fertilizer grade	10 kg/ha	9 (lb/acre)	$82 ($33)	5-8	$10-17 ($4-7)
• fine grade	10 kg/ha	9 (lb/acre)	$59 ($24)	5-8	$7-12 ($3-5)
	5 kg/ha	4.5 (lb/acre)	$30 ($12)	3-5	$6-10 ($2-4)
EDTA Chelate:	2.2 litres/acre		$25 ($10)	1	$25 ($10)
	1.1litres/acre		$13 ($5)	1	$12 ($5)
Sequestered Chelate	2.1litres/acre		$15 ($6)	1	$15 ($6)

Economic Considerations

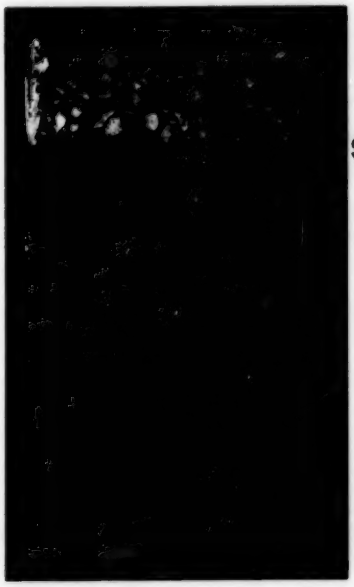
The price of copper varies considerably between the liquid and granular (sulphate) forms. When the residual benefit of the sulphate form is considered, this difference is minimal. The price of copper sulphate has risen in the past years and is likely to continue to increase. Table 5 provides an estimated cost for the recommended treatments, based on available prices as of spring 1989. The cost of application time and equipment are not included.

Mixing Copper Fertilizer with Other Products

Mixing of copper with other fertilizer products is sometimes undertaken to save time and field operations. Care must be taken to avoid incompatible mixtures and to ensure even product application:

Copper Sulphate:

- Copper sulphate should not be mixed with urea fertilizer (46-0-0) because the two react to form a sludge, especially under humid conditions. Fertilizer grade copper sulphate can be successfully blended with monammonium phosphate (11-55-0) or potash (0-0-60). However, phosphate and potash are much more effective when placed in bands, whereas banding is not recommended for any copper product because the high concentrations of copper may induce poor germination and seedling injury.
- When blended, fine granular copper sulphate is prone to separating out in the fertilizer box and poor distribution of copper results.



Different granule sizes of copper sulphate fertilizer available on the market.

- Addition of copper sulphate to liquid fertilizer formulations should be avoided since it often results in precipitation of insoluble copper products which are largely plant unavailable.
- Due to the many problems which can occur when copper sulphate is mixed with other products (uneven blends, poor distribution, unfavorable reactions with urea or liquid fertilizers, storage problems) a separate application of copper sulphate is recommended.
- Chelate products may be mixed with some liquid fertilizers and herbicides to be applied in a one-step process. However, use only registered mixes to be sure of the physical compatibility of the specific chemicals used. Also, be advised that crop tolerance may be lower to a mixture of fertilizer and chemical than to separate applications. Consult with your local herbicide or fertilizer representative.

Summary

Copper deficiencies often occur on peat soils in Manitoba. They result in reduced or limited yield potential. Copper fertilization usually results in yield increases on copper deficient fields, provided adequate amounts of the major nutrients are applied. Soil and tissue analysis, as well as visual copper deficiency symptoms are useful in determining the need for copper. Copper may be applied to a small area of the field perhaps 2-4 hectares (5-10 acres), to determine if the increase in gross income exceeds the cost of fertilization. When evaluating the cost of various copper product, consider the long-term residual benefits.

Warning

Copper sulphate has a corrosive effect on the human body if inhaled or swallowed. Sore throat, coughing, chills, and shortness of breath are common symptoms. As with all agricultural chemicals, common sense is stressed when handling products. Areas of skin which come in contact with copper sulphate should be washed with soap or detergent as soon as possible.

Contaminated clothing should be removed and laundered separately. If the eyes have been exposed, they should be flushed with large amounts of water. Inhalation or ingestion of copper sulphate which produces any feeling of illness is reason to consult a physician as soon as possible.

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